

CHAPTER II - RECONNAISSANCE AND FIXES

1. GENERAL

The Joint Typhoon Warning Center depends on reconnaissance to provide necessary, accurate, and timely meteorological information in support of advisories, alerts and warnings. JTWC relies primarily on three reconnaissance platforms: aircraft, satellite, and radar. In data rich areas, synoptic data are also used to supplement the above. Optimum use of all available reconnaissance resources is obtained through the Selective Reconnaissance Program (SRP); various factors are considered in selecting a specific reconnaissance platform including capabilities and limitations, and the tropical cyclone's threat to life and property both afloat and ashore. A summary of reconnaissance fixes received during 1988 is included in Section 6 of this chapter.

2. RECONNAISSANCE AVAILABILITY

a. AIRCRAFT

Due to budgetary constraints, 1987 was the final year for dedicated aircraft weather reconnaissance in the western North Pacific. The thrust in 1988 was to increase the frequency and reliability of commercial/military airways meteorological reports, thus enhancing synoptic analysis, particularly in data sparse regions.

Limited aircraft of opportunity were available in the western North Pacific, in 1988, for use as synoptic track missions. Aircraft of opportunity can provide direct measurements of standard pressure-level heights, temperature and flight-level wind data. These data, plus the use of airborne radar, can provide the forecaster vital information on changing tropical cyclone characteristics.

b. SATELLITE

Satellite fixes from Air Force/Navy ground sites and Navy ships provide day and night coverage in JTWC's area of responsibility. Interpretation of this satellite imagery provides tropical cyclone positions and estimates of current and forecast intensities through the Dvorak technique.

c. RADAR

Land-based radar remotely senses and maps precipitation within tropical cyclones in the proximity (usually within 175 nm (324 km)) of radar sites in the Republic of the Philippines, Taiwan, Hong Kong, Japan, South Korea, Kwajalein and Guam. In 1987 the USAF upgraded the radars at Yongsan AB, South Korea; Yokota AB, Japan; Kadena AB, Okinawa, Japan; and Andersen AFB, Guam. (The upgrade included increased range, continuous clockwise or counterclockwise scan, a range height indicator to an altitude of 21 km (13 nm) in 1 km (0.6 nm) intervals, a digital video integrator/processor, range normalization, a color enhanced digital remote scope and local area/operations area mapping program.) These new radars are a welcome improvement to the existing network. The next upgrade will be the arrival of the first next generation Doppler radars in the early 1990's.

d. SYNOPTIC

JTWC also determines tropical cyclone positions based on the analysis of the surface/gradient-level synoptic data. These positions were helpful in situations where the vertical structure of the tropical cyclone was weak or accurate surface positions from aircraft or satellite were not available.

3. AIRCRAFT RECONNAISSANCE SUMMARY

There were no vortex fix or investigative missions flown into western North Pacific

tropical cyclones in 1988. A synoptic track and airborne radar fix were provided on Typhoon Roy (01W) in January by aircraft of opportunity. These data described the mid-level steering flow and center location.

4. SATELLITE RECONNAISSANCE SUMMARY

The USAF provides satellite reconnaissance support to JTWC through the DMSP Tropical Cyclone Reporting Network (DMSP Network), which consists of tactical sites and a centralized facility. Tactical DMSP sites monitoring DMSP, NOAA and geostationary satellite data are located at Nimitz Hill, Guam; Clark AB, Republic of the Philippines; Kadena AB, Okinawa, Japan; Osan AB, Republic of Korea; and Hickam AFB, Hawaii. These sites provide a combined coverage that includes most of JTWC's area of responsibility in the western North Pacific, from near the dateline westward to the Malay Peninsula. For the remainder of its AOR, JTWC relies on the AFGWC to provide coverage using stored satellite data. The Naval Oceanography Command Detachment, Diego Garcia, furnishes interpretation of NOAA polar orbiting coverage in the central Indian Ocean and USN ships equipped for direct satellite readout contribute supplementary support.

AFGWC, located at Offutt AFB, Nebraska, is the centralized member of the DMSP network. In support of JTWC, AFGWC processes stored imagery from DMSP and NOAA spacecraft. Stored imagery is recorded onboard the spacecraft as they pass over the earth and later down-linked to AFGWC via a network of command readout sites and communication satellites. This enables AFGWC to obtain the coverage necessary to fix all tropical cyclones within JTWC's AOR. AFGWC has the primary responsibility to provide tropical cyclone reconnaissance over the entire Indian Ocean, southwest Pacific, and the area near the dateline in the western North Pacific Ocean. Additionally, AFGWC can be tasked to provide tropical cyclone support in the entire western North Pacific as backup to

coverage routinely available in that region.

The hub of the DMSP network is Detachment 1, First Weather Wing (Det 1, 1WW), colocated with JTWC at Nimitz Hill, Guam. Based on available satellite coverage, Det 1, 1WW is responsible for coordinating satellite reconnaissance requirements with JTWC and tasking the individual network sites for the necessary tropical cyclone fixes, current intensity estimates and forecast intensities. When a particular satellite pass is selected to support the development of JTWC's next tropical cyclone warning, two sites are tasked to fix the tropical cyclone from the same pass. This "dual-site" concept provides the necessary redundancy to virtually guarantee JTWC a satellite fix on the tropical cyclone.

The network provides JTWC with several products and services. The main service is one of monitoring the AOR for indications of tropical cyclone development. If an area exhibits potential for development, JTWC is notified. Once JTWC issues either a Tropical Cyclone Formation Alert or warning, the network is tasked to provide three products: tropical cyclone positions, current intensity estimates and forecast intensities. Each satellite tropical cyclone position is assigned a Position Code Number (PCN) to indicate the accuracy of the fix position. The PCN is determined by the availability of visible landmarks in the image that can be used as references for precise gridding and the degree of organization of the tropical cyclone's cloud system (Table 2-1).

TABLE 2-1

POSITION CODE NUMBERS (PCN)

PCN	METHOD FOR CENTER DETERMINATION/GRIDDING
1	EYE/GEOGRAPHY
2	EYE/EPHEMERIS
3	WELL DEFINED CIRCULATION CENTER/GEOGRAPHY
4	WELL DEFINED CIRCULATION CENTER/EPHEMERIS
5	POORLY DEFINED CIRCULATION CENTER/GEOGRAPHY
6	POORLY DEFINED CIRCULATION CENTER/EPHEMERIS

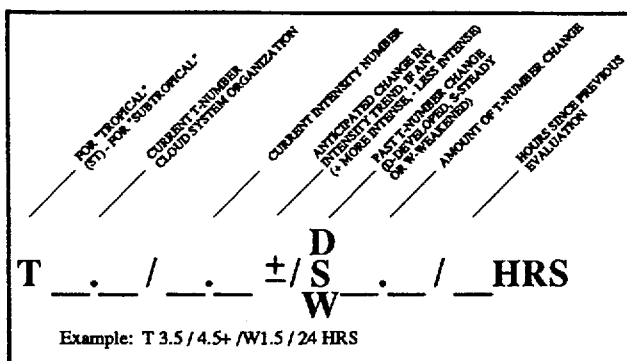


Figure 2-1. Dvorak code for communicating estimates of current and forecast intensity derived from satellite data. In the example, the current "T-number" is 3.5, but the current intensity is 4.5. The cloud system has weakened by 1.5 "T-numbers" since the previous evaluation conducted 24-hours earlier. The plus (+) symbol indicates an expected reversal of the weakening trend or very little further weakening of the tropical cyclone during the next 24-hour period.

Starting in 1987, Detachment 1, First Weather Wing increased the number of estimates of the tropical cyclone's current intensity from two to four per day once a tropical cyclone formation alert or tropical cyclone warning was issued. Current intensity estimates and 24-hour intensity forecasts are made using the Dvorak technique (NOAA Technical Report NESDIS 11) for both visual and enhanced infrared imagery (Figure 2-1).

Figure 2-2 shows the status of operational polar orbiting spacecraft. Two DMSP spacecraft were operational in 1988. The year began with one operational DMSP satellite, the 19543 (F8) spacecraft. After overheating forced a temporary shutdown on 3 December 1987, the Special (passive) Sensor, Microwave Imager (SSM/I) on the F8 spacecraft was reactivated in mid-January 1988. The 20542 (F9) DMSP satellite was launched 3 February as a replacement for the 18541 (F7) satellite, which failed 17 October 1987. The thermal channel used for intensity estimates began to degrade shortly after launch and was of marginal use at year's end. The NOAA 10 spacecraft performed

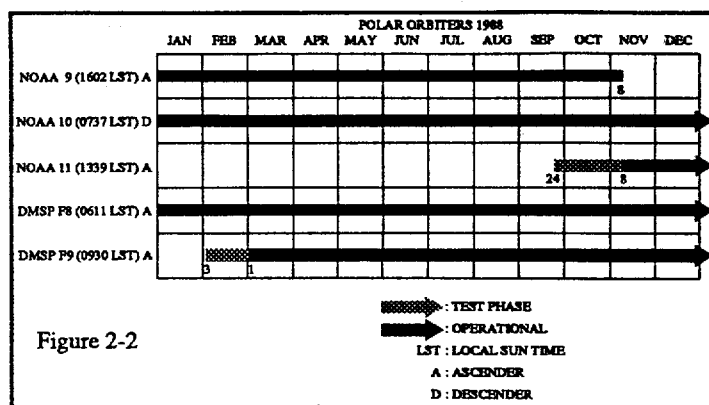


Figure 2-2

well throughout the year. The NOAA 11 was launched 24 September and replaced the aging NOAA 9 satellite on 8 November.

During 1988, data from the DMSP network was the primary input to warnings and best tracks in the western North Pacific. This increased emphasis on satellite data resulted in almost all the warnings being based on satellite reconnaissance.

The DMSP network provided JTWC with a total of 2,044 satellite fixes on 27 tropical cyclones in the western North Pacific Ocean. In addition, 117 fixes were made on tropical cyclones in the North Indian Ocean and 1144 in the southern hemisphere. A comparison of those fixes and their corresponding best tracks is shown in Tables 2-2A and 2-2B. (Note: Those fixes which were out of limits when compared with the best track are not included.) The network also provided an additional 224 fixes on tropical disturbances which did not develop into significant tropical cyclones. The standard relationship between tropical cyclone "T-number", maximum surface wind speed (Dvorak, 1984) and minimum sea-level pressure (Atkinson and Holliday, 1977) is outlined in Table 2-3.

TABLE 2-2A

MEAN DEVIATION (NM) OF ALL SATELLITE DERIVED TROPICAL CYCLONE
POSITIONS FROM JTWC BEST TRACK POSITIONS IN THE
WESTERN NORTH PACIFIC AND NORTH INDIAN OCEANS
(NUMBER OF CASES IN PARENTHESES)

PCN	WESTERN NORTH PACIFIC OCEAN		NORTH INDIAN OCEAN	
	<u>1978-1987 AVERAGE</u>	<u>1988 AVERAGE</u>	<u>1980-1987 AVERAGE</u>	<u>1988 AVERAGE</u>
1	14.2 (1737)	13.4 (78)	16.9 (42)	7.2 (2)
2	15.6 (2582)	13.7 (337)	16.9 (9)	11.3 (4)
3	21.2 (2488)	18.5 (82)	24.8 (34)	24.5 (8)
4	22.2 (2047)	16.7 (281)	45.1 (21)	25.2 (5)
5	37.5 (4294)	30.2 (185)	38.3 (313)	37.4 (30)
6	38.4 (5023)	30.9 (973)	40.5 (417)	38.7 (64)
1&2	15.0 (4319)	13.6 (415)	17.0 (51)	9.9 (6)
3&4	21.7 (4535)	17.1 (363)	32.5 (55)	24.8 (13)
5&6	38.0 (9317)	30.8 (1158)	39.6 (730)	38.3 (94)
TOTAL	28.4 (18171)	24.5 (1936)	37.8 (836)	35.2 (113)

TABLE 2-2B

MEAN DEVIATION (NM) OF ALL SATELLITE DERIVED TROPICAL CYCLONE
POSITIONS FROM JTWC BEST TRACK POSITIONS IN THE
WESTERN SOUTH PACIFIC AND SOUTH INDIAN OCEANS
(NUMBER OF CASES IN PARENTHESES)

PCN	<u>1985 - 1987 AVERAGE</u>	<u>1988 AVERAGE</u>
1	16.6 (82)	15.2 (21)
2	16.1 (442)	17.9 (122)
3	35.9 (112)	25.4 (13)
4	27.0 (408)	27.1 (130)
5	40.8 (474)	39.2 (74)
6	36.4 (2938)	40.1 (713)
1 & 2	16.2 (524)	17.5 (143)
3 & 4	28.9 (520)	26.9 (143)
5 & 6	37.0 (3412)	40.0 (787)
TOTALS	33.6 (4456)	35.3 (1073)

TABLE 2-3

MAXIMUM SUSTAINED WIND SPEED (KT)
AS A FUNCTION OF DVORAK CURRENT AND
FORECAST INTENSITY NUMBER AND
MINIMUM SEA-LEVEL PRESSURE (MSLP)

TROPICAL CYCLONE INTENSITY NUMBER	WIND SPEED	MSLP (NW PACIFIC)
0.0	<25	- - - -
0.5	25	- - - -
1.0	25	- - - -
1.5	25	- - - -
2.0	30	1000
2.5	35	997
3.0	45	991
3.5	55	984
4.0	65	976
4.5	77	966
5.0	90	954
5.5	102	941
6.0	115	927
6.5	127	914
7.0	140	898
7.5	155	879
8.0	170	858

5. RADAR RECONNAISSANCE SUMMARY

Twelve of the twenty-seven significant tropical cyclones in the western North Pacific during 1988 passed within range of land-based radar with sufficient cloud pattern organization to be fixed. The land-based radar fixes that were obtained and transmitted to JTWC totaled 430. (Only one radar fix was obtained by aircraft of opportunity.)

The WMO radar code defines three categories of accuracy: good (within 10 km (5 nm)), fair (within 10-30 km (5-16 nm)), and poor (within 30-50 km (16-27 nm)). Of the 428 radar fixes encoded in this manner, 169 were good, 120 were fair, and 139 were poor. Compared to JTWC's best track, the mean vector deviation for land-based radar sites was 19 nm (35 km). Excellent support from the radar network through timely and accurate radar fix positioning allowed JTWC to track and forecast tropical cyclone movement through even the most difficult erratic tracks.

The availability of data from radar sites in the Republic of Philippines was of concern. In 1988 these radar sites provided a valuable but limited number of reports on tropical cyclones. Reports were received from only two stations, in contrast to five in 1987. As in previous years, no radar reports were received on North Indian Ocean or southern hemisphere tropical cyclones.

6. TROPICAL CYCLONE FIX DATA

A total of 2,474 fixes on twenty-seven western North Pacific tropical cyclones and 117 fixes on five North Indian Ocean tropical cyclones were received at JTWC. Table 2-4A and Table 2-4B delineate the number of fixes per platform for each individual tropical cyclone for the western North Pacific and North Indian Oceans respectively. Season totals and percentages are also indicated. (Table 2-4C provides the same information for the South Pacific and South Indian Oceans.)

TABLE 2-4A

**WESTERN NORTH PACIFIC
FIX PLATFORM SUMMARY FOR 1988**

<u>WESTERN NORTH PACIFIC</u>	<u>SATELLITE</u>	<u>RADAR</u>	<u>TOTAL*</u>
TY ROY (01W)	155	60	215
TY SUSAN (02W)	75	35	110
TD 03W (03W)	29	0	29
TY THAD (04W)	96	26	122
TS VANESSA (05W)	76	8	84
TY WARREN (06W)	141	30	171
TS AGNES (07W)	33	0	33
TS BILL (08W)	43	0	43
TS CLARA (09W)	36	0	36
TY DOYLE (10W)	96	0	96
TS ELSIE (11W)	39	0	39
TY FABIAN (12W)	81	0	81
TS GAY (13W)	21	0	21
TY HAL (14W)	110	18	128
TY ULEKI (01C)	62	0	62
TS IRMA (15W)	51	0	51
TS JEFF (16W)	36	0	36
TS KIT (17W)	51	9	60
TS LEE (18W)	64	8	72
TS MAMIE (19W)	48	0	48
STY NELSON (20W)	125	184	309
TY ODESSA (21W)	104	0	104
TY PAT (22W)	81	9	90
TY RUBY (23W)	140	42	182
TY SKIP (24W)	133	0	133
TY TESS (25W)	55	0	55
TS VAL (26W)	63	1	64
TOTALS	2044	430	2474
PERCENTAGE OF TOTALS	83%	17%	100%

* NO AIRCRAFT OR SYNOPTIC FIXES WERE RECEIVED

TABLE 2-4B

**NORTH INDIAN OCEAN
FIX PLATFORM SUMMARY FOR 1988**

<u>TROPICAL CYCLONE</u>	<u>SATELLITE*</u>
TC 01A	20
TC 02B	15
TC 03B	11
TC 04B	55
TC 05B	16

TOTAL NUMBER OF FIXES 117

* NO SYNOPTIC FIXES WERE RECEIVED

TABLE 2-4C

SOUTH PACIFIC AND SOUTH INDIAN OCEANS
FIX PLATFORM SUMMARY FOR 1988

<u>TROPICAL CYCLONES</u>	<u>SATELLITE</u>	<u>SYNOPTIC</u>	<u>TOTAL**</u>
TC 01S - - - -	65	0	65
TC 02S - - - -	14	0	14
TC 03S ARINY	79	0	79
TC 04P - - - -	37	0	37
TC 05S BERNANDRO	43	0	43
TC 06P AGI	97	0	97
TC 07P ANNE	93	2	95
TC 08S CALIDERA	18	0	18
TC 09S DOAZA	59	0	59
TC 10S FREDERIC	47	0	47
TC 11S GWENDA *	95	0	95
TC 12P CHARLIE	111	0	111
TC 13P BOLA	123	0	123
TC 14S - - - -	21	0	21
TC 15P CILLA	14	0	14
TC 16S GASITAO	64	0	64
TC 17S - - - -	2	0	2
TC 18S HELY	11	0	11
TC 19P DOVI	82	0	82
TC 20S IARISENA	24	0	24
TC 21S - - - -	25	0	25
 TOTAL NUMBER OF FIXES	 1144	 2	 1146

* ALSO NAMED EZENINA

** NO RADAR FIXES WERE RECEIVED

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